UNIVERSITY COLLEGE TATI

UNIVERSITY COLLEGE TATI (UCTATI)

FINAL EXAMINATION QUESTION BOOKLET	
COURSE CODE	: DEE 3143
COURSE	: CONTROL SYSTEMS
SEMESTER/SESSION	: 2-2024/2025
DURATION	: 3 HOURS

Instructions:

1. This booklet contains 4 questions. Answer **ALL** questions.
2. All answers should be written in answer booklet.
3. Write legibly and draw sketches wherever required.
4. If in doubt, raise your hands and ask the invigilator.

DO NOT OPEN THIS BOOKLET UNTIL YOU ARE TOLD TO DO SO

THIS BOOKLET CONTAINS 8 PRINTED PAGES INCLUDING COVER PAGE

QUESTION 1

a) Illustrate the basic idea of a control system. (4 marks)

b) Given an elevator as a control system as in Figure 1. Describe the controlled variable, input and output for the system.

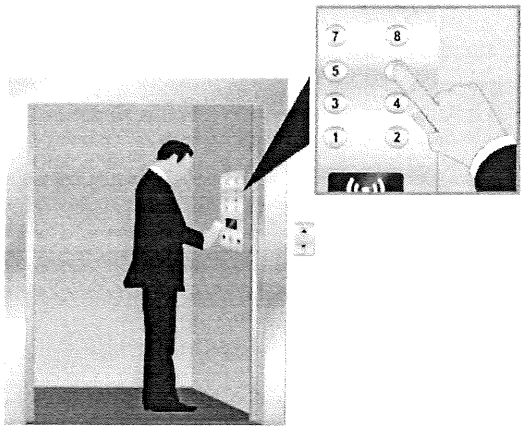

Figure 1

(6 marks)

c) There are two categories of control system available which are the open loop control system and closed loop control system.

i. Draw the block diagram for both categories. (6 marks)

ii. Give one (1) example for each category. (2 marks)

QUESTION 2

a) Illustrate summing junction, blocks and take off point. (3 marks)

b) Differentiate between forward and feedback path by drawing its block. (4 marks)

c) An open loop system consists of three elements in **parallel**. The elements having the transfer functions of 4/s, (s+1)/(s+3) and (s+3)/(s+7). Draw the block diagram of this system.

(7 marks)

d) Obtain the equivalent transfer function for Figure 2 below.

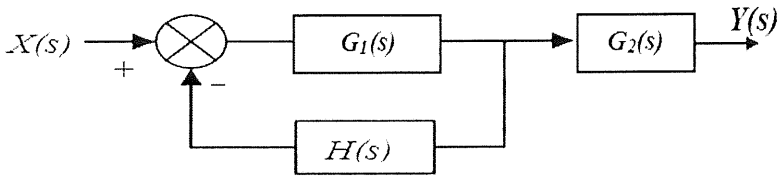

Figure 2

Note that a basic negative feedback form will have the equivalent transfer function of $G(s)/(1+G(s)H(s))$.

(4 marks)

QUESTION 3

a) Illustrate the location of poles and zeros for the following system on the s-plane.

i. $F(s) = \frac{(s-3.8)}{(s+3.8)}$ (4 marks)

ii. $F(s) = \frac{(s+2)}{s^2+6s+49}$ (6 marks)

iii. $F(s) = \frac{25}{s^2+25}$ (3 marks)

b) For the poles shown on s-planes in Figure 3, state which pole/ poles plot will provide a stable system.

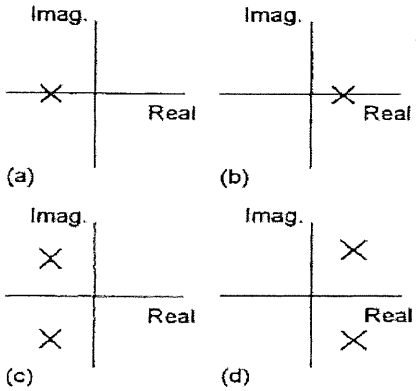

Figure 3

(4 marks)

c) Given a transfer function as follow;

$$G(s) = \frac{0.9}{s+9}$$

Find the:

i. Time constant, τ (2 marks)

ii. Rise time, T_r (2 marks)

iii. Settling time, T_s (2 marks)

d) A second order system having a transfer function of:

$$G(s) = \frac{81}{s^2 + 13s + 81}$$

Find the:

i. Natural angular frequency, ω_n (2 marks)

ii. Damping factor, ζ (3 marks)

e) The step response plot of the system in 3(d) is as shown in Figure 4.

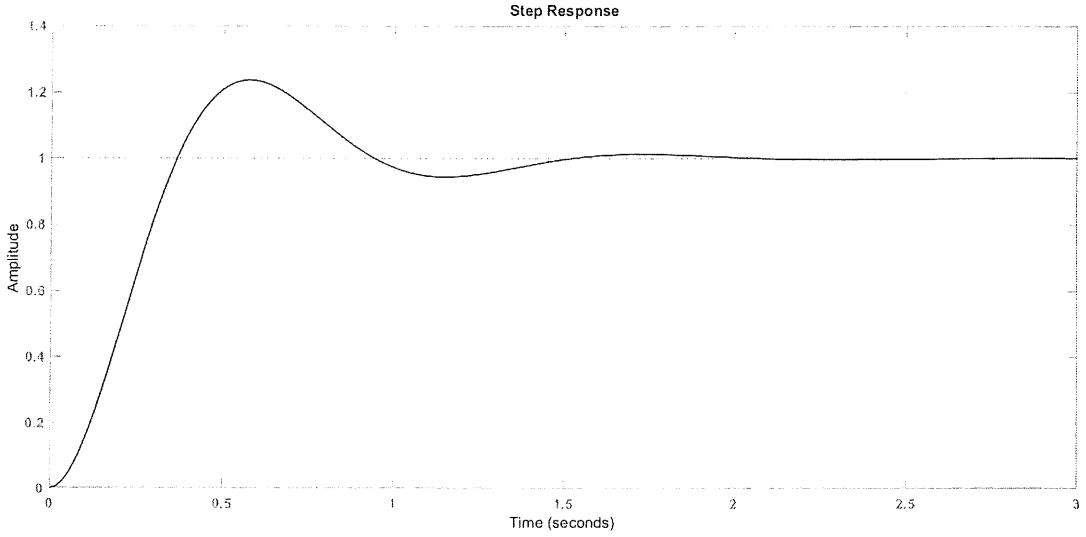

Figure 4

Show each of the following characteristics:

i. Overshoot (2 marks)

ii. Peak time (2 marks)

iii. Rise time (4 marks)

Note: Please label each of the following characteristics.

QUESTION 4

a) Figure 5 shows the bode plot for a system. Find the:

i. Gain margin (4 marks)

ii. Phase margin (4 marks)

iii. Stability of the system (2 marks)

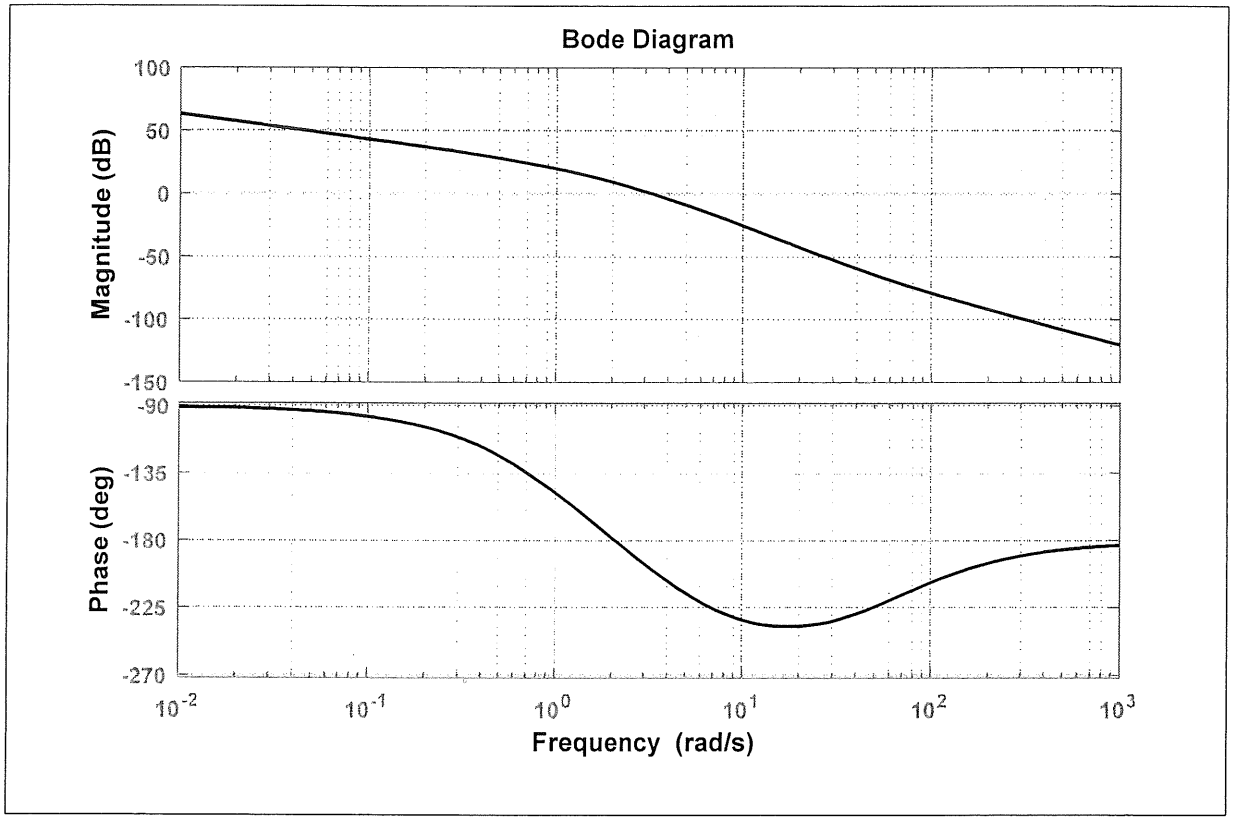

Figure 5

b) Describe the function for each following controller:

i. Proportional controller (2 marks)

ii. Integral controller (2 marks)

iii. Derivative controller (2 marks)

c) One of the methods to tune the PID controller is the Ziegler Nichols (Z-N) methods. By using this method, find the gains for the followings if the ultimate gain = 150 and the oscillation period = 4 seconds.

i. P controller (2 marks)

ii. PI controller (3 marks)

iii. PD controller (3 marks)

iv. PID controller (4 marks)

----------End of question----------

APPENDIX A

1. Basic negative feedback: $\frac{G(s)}{1-G(s)H(s)}$

2. $s_{1,2} = -\zeta\omega_n \pm \omega_n\sqrt{\zeta^2 - 1}$

3. $t_r = \frac{2.2}{a}$ / $t_r = \frac{\pi}{2\omega_n\sqrt{1-\zeta^2}}$

4. $t_p = \frac{\pi}{\omega_n\sqrt{1-\zeta^2}}$

5. $t_s = \frac{4}{a}$ / $t_s = \frac{4}{\zeta\omega_n}$

6. $\%\,\mathrm{OS} = \mathrm{e}^{-\left(\zeta\pi/\sqrt{1-\zeta^2}\right)} \mathrm{x}\, 100$

7. $\mathcal{L}[f(t)] = F(s) = \int_0^\infty f(t)e^{-st}\,dt$

8. $\mathcal{L}^{-1}[F(s)] = f(t) = \frac{1}{2j}\int_{-\infty}^{\infty} F(s)e^{st}\,d(s) = ft)u(t)$

9. Z-N Method

Ziegler Nichols Method			
Control Type	K_P	K_i	K_d
P	$0.5K_u$	-	-
PI	$0.45K_u$	$1.2K_p/T_u$	-
PD	$0.8K_u$	-	$K_pT_u/8$
PID	$0.6K_u$	$2K_p/T_u$	$K_pT_u/8$